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A BOTANICAL SURVEY OF THE HURON RIVER VALLEY.

III. THE PLANT SOCIETIES OF THE BAYOU AT YPSILANTI, MICHIGAN.

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(WITH MAP AND FIVE FIGURES)

INTRODUCTION.

THE materials for the present paper were collected from a detailed survey of an area of sixty acres, known as the "bayou," which lies to the west and southwest of the Ypsilanti Highland Cemetery. It includes steep slopes, a large bayou, with a stretch of floodplain and stream, embracing a wide variety of conditions. From a reconnaissance of the entire course of the stream, it was found that many of the ecological conditions occurring from the source to the mouth were represented at the bayou area. In this small territory, the plant societies have reached an unmolested development, exceptionally favorable for their study.

The results here presented are the outcome of an attempt (1) to determine what plant societies are clearly represented, paying special attention to those which are found also in other parts of the stream course; (2) to determine so far as possible, from existing evidence, the influence of the factors of the environment which, both past and present, may account for their presence or explain their origin. Naturally the stream course societies are considered, leading to a different line of study from the two previous papers of this series, in which the glacial lakes included within the valley have been made the subject of treatment. A careful record of all species found upon the area was kept and a complete herbarium made, which is to be left at the herbarium of the University of Michigan. The work was carried on under the direction of Professor V. M. SPALDING, and the writer desires to express his indebtedness to him for many helpful suggestions.

DESCRIPTION.

I. TOPOGRAPHY AND PHYSICAL GEOGRAPHY.—In the vicinity of Ann Arbor, Ypsilanti, and other parts of its lower course, the Huron River flows through a wide valley with flats bordered by bluffs, often

very steep, which rise to a height of some 90 feet above the water. The portion mapped is a fair type of the portion between Ypsilanti and Rawsonville, a village four miles southeast of the bayou. Throughout this part of its course the stream makes a number of loops and bends that would cause a boat to journey over ten miles to reach a linear distance of four.

2. GEOLOGICAL HISTORY.

—The cemetery bluff, shown in the upper middle part of the *map* (p. 266) and also in *fig. 1*, is a portion of an old sand bar, "which trends north about a mile, and connects with a beach leading in from the west, which forms the continuation of the western or main ridge found south of the Huron River."¹ This beach is one of two marking the northwest shore

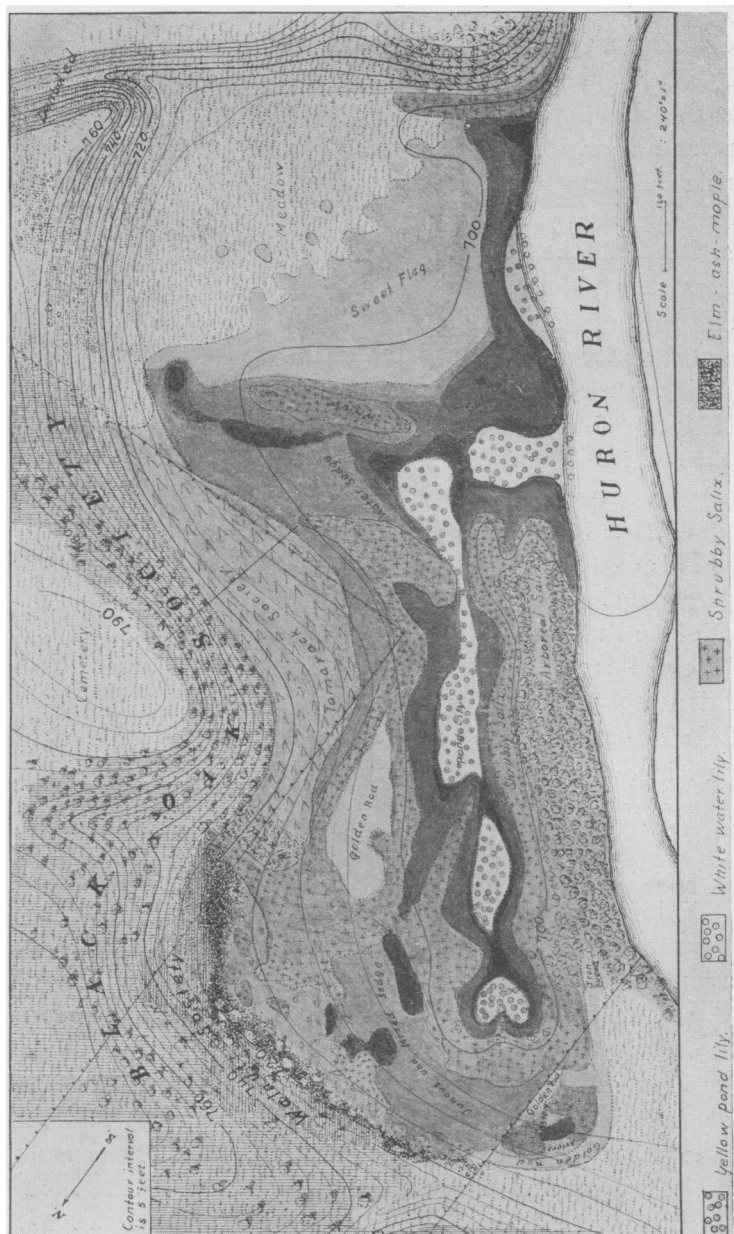


FIG. 1.—The cemetery bluff, shown in the upper middle part of map; a portion of an ancient sand bar.

of Lake Maumee, which was the first of a series of large glacial lakes formed in this region with the retreat of the glacial ice. Later a change of outlet permitted the water to subside, forming Lake Whittlesey at a level some 75 feet below the upper Maumee beach. During its existence this lake formed the well defined Belmore beach, meeting the river about three miles southeast of the bayou. Still farther subsidence of the waters brought about the formation of Lake Warren, by whose waves the Forest beaches were made at levels of 60 to 90 feet below the Belmore, and at a distance of more than seven miles further down stream. From this point there is a stretch of fixed sand dunes extending to within eight miles of Lake Erie.

During the Lake Maumee stages, ice and water had not yet uncovered the bayou area, except for high points of the sand bar. During the Lake Whittlesey stage, the stream was cutting its first

¹ LEVERETT, F., Glacial formations and drainage features of the Erie and Ohio Basins. U. S. Geol. Survey 41:chaps. 14-16.



bluffs. As the waters had now subsided only about 50 feet, the base of the cemetery bluff was as yet under water; but the part exposed was free for the first vegetation to come in. It was not until the Lake Warren stage that the river, through the fall of waters at its mouth, cut still deeper in its channel and exposed the base of the cemetery bluff. The land area which was for a time submerged

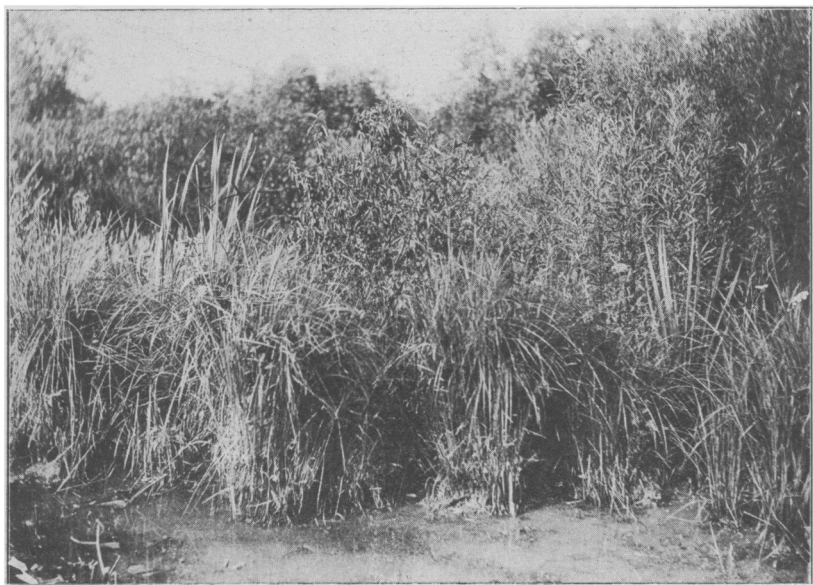


FIG. 2.—*Carex stricta*, the deepest water sedge here, appears on the advance of the line of sedges, and forms tufts of great compactness and strength.

and then exposed by degrees forms the large relatively level portion of southeast Michigan, extending for thirty miles or more west from Lake Erie and the Detroit River, and nearly the same distance southward into Ohio. Westward from the basin area the surface is broken up into countless hills, ridges, and kettle-holes, characteristic of the morainal regions. It has been known for some time that the vegetation in this portion of the Huron-Erie basin is distinct from that of the morainal area, with a line of tension in sight of the east limits of the city of Ypsilanti; but an explanation of this has not yet been offered, and does not fall within the limits of the work in hand.

3. THE SOILS.—The distribution of surface soils is important because of the relations existing between soil types and plant societies. The floodplain, while having areas of peaty earth about the center and between the ponds and bluff, with an outwash of sand at the northwest and southeast, is fundamentally of compact till, which underlies the whole region and frequently appears elsewhere at the surface. The east bluffs are more porous, being composed of gravel or sand. A long ridge of mineral soil reaches from the northwest, forming a low barrier along the stream to the marsh about the bay, where it is bordered by peat-like earth. Humus is present everywhere except on the washed slopes of the bluffs. At the east is a line 600 feet in length, following the base of the cemetery bluff, where sand borders the till below with the sharpness of exposed strata. A profile was made through *B* (map), shown in fig. 3, which further explains this peculiarity in the structure of the

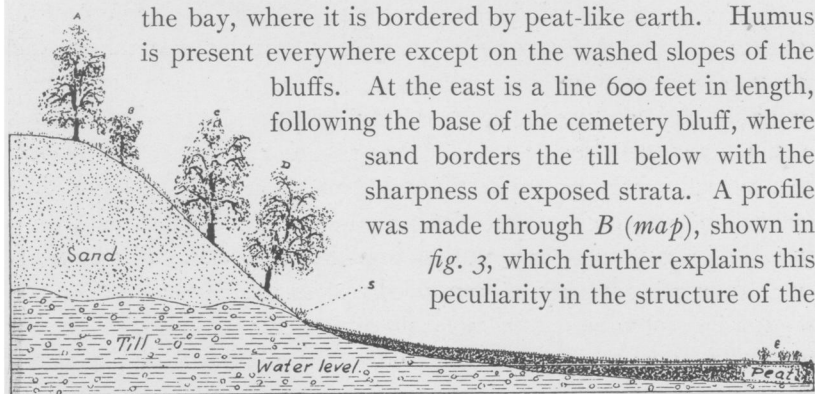


FIG. 3.—Profile through *B*, map, showing influence of plant associations in preventing the outwash of soil, and in the formation of beds of peat; *A*, black oak; *B*, black locust; *C*, yellow oak (*Quercus acuminata*); *D*, bur oak; *S*, seepage springs; *E*, shrubs (*Betula pumila*); scale 60 feet to the inch.

bluff. The sand or gravel-capped bluff, with seepage springs along its soil line, and with its structure plainly revealed by the plant societies which inhabit its slope, occurs commonly in the valley.

4. SOIL WATER.—The conditions of soil moisture, as influenced by varying soils and differences of elevation, have an obvious present bearing upon the distribution of plant societies. Conditions of extreme dryness are to be found in places along the brink of the steeper bluffs, where the combined effects are felt from the porous nature of the soil, elevation, and exposure to drying effects of wind and heat. More soil moisture is found on descending the slopes, and the change may be abrupt along soil lines where seepage springs occur. There is a slow but constant flow and percolation of spring

water from the base of the bluffs to the central ponds, giving rise to one of the main differences between the conditions existing in the bayou and the usual kettle-hole swamp or bog in which water is more or less standing. The ridge along the west is usually free from surface water, although always moist.

THE PLANT SOCIETIES.

The vegetation of the bayou and bluffs consists of a number of plant societies, which may be treated under three heads.

1. PEAT-FORMING SOCIETIES.—Under this head are included the societies commencing with the deepest submerged vegetation and reaching landward as far as the elms, red and green ash, and silver maple of the floodplain. A connected account of each in its order is given because the vertical succession of societies which occurs here seems to have been a common one on the wide floodplain areas below Ypsilanti, and would appear to possess some unusual features in the light of what has been written regarding the floodplains of other river valleys. This group comprises 131 species, or 32 per cent. of all species found upon the area surveyed. Seven distinct societies may be distinguished in order as follows, the number of species being given in parenthesis: 1, pondweed (7); 2, waterlily (5); 3, water smartweed (6); 4, *Typha-Sparganium* (10); 5, water sedge (19); 6, willow (71); 7, tamarack (13); total 131 species.

The first society is submerged, consisting chiefly of species of *Potamogeton*, and occurs only in the stream. The growth offers resistance to the flow of water, checking the current, and causes deposit of suspended particles in addition to that arising from vegetable decay. Following upon the submerged society, there appears one of floating plants, which still further checks the current. The waterlilies secure a firm anchorage. The white waterlily (*Castalia odorata*) is more common in the current. The yellow pond lily (*Nymphaea advena*) commences just back of this and occupies the bays where the current moves more slowly or is scarcely perceptible. The exchange of species in relation to habitat is best shown between the bay and the current (*map*). With the presence of the waterlily society, there is a marked tendency to secure room near the water surface. The *potamogetons* appear to rely on the anchorage offered

by the waterlilies, sending out long stems with leaves clustered above. In this zone, when the surface of the water is quiet, occur such plants as *Utricularia*, *Lemna*, *Spirodela*, and *Riccia*. Peat-like material rapidly accumulates below as growth proceeds above. The interwoven rootstocks are firm enough to support the weight of a person. The several kinds of water smartweed are most active in forming this mat, although the yellow pond lilies add a good deal of firmness.

At length the intervening space between the surface growth above and the substratum below becomes filled in with an oozy accumulation of peat, and gradually two marsh societies appear, the *Typha-Sparganium* and the water sedge. These marsh plants are characterized by the possession of thickly matted root systems and rhizomes. *Carex stricta* is the deepest water sedge here. It appears on the advance of the line of sedges and forms tufts of great compactness and strength. These tufts persist through subsequent changes that occur, and long after the death of the sedge itself, finally become covered with *Potentilla fruticosa* and turf-forming grasses. They give rise to the peculiar mound or hummock configuration so characteristic of the numerous valley meadows which have been built up in this way. Sedges build up the peat bed in two ways: (1), by the death of the aerial parts; and (2) by the death of the roots and rootstocks, the latter often the more rapid of the two processes.

As the surface becomes rather free from water and firm, there appear the first woody types. Shrubby species of *Salix* are the first to grow in abundance, covering many parts so densely that other forms are almost excluded. *Rhus venenata*, *Naumburgia thyrsiflora*, *Asclepias incarnata*, and *Scutellaria lateriflora* act as pioneers in seizing decaying timbers, islands of sedge, and similar places of advantage. This results in the formation of a willow or drained swamp society, the vegetation of which is richer in individuals and species than that of any other association. From the map it will be seen that the arboreal species of *Salix* are confined chiefly to the ridge, which is mainly till in this portion. The shrubby kinds, on the other hand, prevail over the beds of black peat bordering the water.

Part of the drained swamp area has culminated in tamarack and other plants with xerophytic characters similar to those characteristic

of the flora of the so-called undrained swamps. This stage does not appear to have been uncommon in the wider parts of the valley, and possesses points of unusual interest. This association forms a crescent-shaped area at the base of the cemetery bluff, commencing with the seepage springs (*fig. 2* and *map*) and reaching stream-ward as far as the water sedge. It is here 700 feet long and 200 feet wide, containing the following species listed in order of their relative abundance: *Scirpus americanus*, *Carex filiformis*, *Koellia flexuosa*, *Lysimachia quadrifolia*, *Campanula aparinoides*, *Lobelia Kalmii*, *Aster junceus*, *Parnassia caroliniana*, *Rhynchospora alba*, *Gerardia paupercula*, *Solidago Riddellii*, *Sarracenia purpurea*, *Larix laricina* (once abundant, but now removed for firewood).

On comparing the composition of this society with that of others, it was found that the above species are peculiar to the one society and occur rarely if at all outside of it. A sharp line of separation occurs between it and neighboring societies. As a whole it may be said that the vegetation is the most distinct of all those studied. With but two exceptions all species are perennials, and a certain likeness of form characterizes the members, as if mutually adapted to xerophytic conditions, causing the vegetation to stand out in contrast with the neighboring broad-leaved hydrophytes. Regarding this group of plant societies the following points are to be noted.

1. Of the whole group, 5 per cent. of the species were found to be submerged, 32 per cent. amphibious, and 63 per cent. terrestrial. The willow society is richest in species, containing more than twice the number of species found in any other society of this group, and slightly more than any society to be discussed later.

2. Of the agencies active in filling the bayou, the first place is assigned to vegetation (*fig. 3*). Not more than one-third the material entering into the composition of earth so formed is inorganic matter, the proportion often being smaller. From the areas of organic soil frequently occurring along the flats it is plain that the process has been as active in past as in present times, converting numerous standing pools and deserted channels into dry land surface supporting a thrifty forest growth.

3. Most of the common species are gregarious, and tension lines are sharply marked.

4. The vertical succession of societies which build up the drained swamp may culminate in tamarack and other plants with xerophytic adaptations.

5. The bayou vegetation is similar to that of like areas along the stream, and only minor differences were brought out; but on comparing this vegetation with that of the glacial lakes about Ann Arbor, the most pronounced differences were discovered when the respective swamp and bog societies were compared. *Andromeda polifolia*, *Chamaedaphne calyculata*, *Arethusa bulbosa*, *Sarracenia purpurea*, *Oxycoccus macrocarpus*, *Drosera rotundifolia*, and sphagnum are common about lakes, but absent or very rare along the stream. In both cases, however, there is a dominance of northern forms.

2. FLOODPLAIN SOCIETIES.—The series of changes taking place in the previous group are continued until swamps and pools disappear, to be replaced by a dense woods of mixed mesophytic species. Three societies appear, often with a more or less zonal arrangement.

(1) *Moist sedge society*.—Turf-forming grasses here make their first appearance, but are not able to replace entirely the terrestrial sedges, which occupy occasional areas.

(2) *Elm-ash-maple society*.—There is little space not occupied by tree growth, except where clearings have been made. *Populus tremuloides* and *P. deltoides* appear early as pioneers, followed later by *Ulmus americana*, *U. pubescens*, *Fraxinus pennsylvanica*, *F. lanceolata*, *F. nigra*, *Acer saccharinum*, *A. rubrum*, *Platanus occidentalis*, and *Tilia americana*; which make up a woods characteristically mixed, dense, and vine-clad. Of the herbaceous forms, only the most shade-enduring kinds with broad thin leaves are to be met with in the forest. Of these *Urticastrum divaricatum*, *Acnida concatenata*, *Adicea pumila*, and *Lobelia cardinalis* are most common.

(3) *Walnut society*.—The most abundant and characteristic tree of this association is *Juglans nigra*, which appears to have been uniformly distributed, and often over three feet in diameter, as shown by stumps. It is one of the arboreal types which shows a tendency to follow along streams or bodies of water. It occurs mixed with *Juglans cinerea*, *Quercus macrocarpa*, *Hicoria minima*, *Quercus platanoidea*, and other species. It was attempted to characterize the group as a bur oak-walnut association. This was

abandoned because the bur oak was found to occur not alone in moist situations, but with equal frequency under much more xerophytic conditions, such as prevail in the oak openings a few miles west from Ann Arbor. However, the bur oak of these drier situations differs in appearance from the walnut association form, which has drooping branches with heavy corky ridges. The walnut society occurs in the better drained parts of the floodplain and for a short distance up from the base of the slopes, as shown in the map. It grows best of all in the coves. Along the tension line nearest the water *Carpinus caroliniana* is common; along the drier tension line *Ostrya virginiana* is rarely absent. The most common associated herbaceous species are *Houstonia ciliolata*, *Mesadena atriplicifolia*, *Allium canadense*, *Verbesina alternifolia*, *Homalocenchrus virginicus*, *Falcata comosa*, and *F. Pitcheri*.

As a whole the vegetation of the floodplain is mesophytic. Its growth differs from that of the peat-forming group in being mainly forest, in the tendency of its species to grow in mixture, in possessing a greater number of southern forms in its composition, and in the greater shade endurance of its species. The composition does not vary much in similar parts of the valley, but certain elements occur which serve to distinguish the stream-course type from that which occurs in the more remote parts of the valley, where mesophytic associations are found. *Platanus occidentalis*, *Juglans nigra*, *Hicoria laciniosa*, *Houstonia ciliolata*, *Quercus acuminata*, *Meibomia canadensis*, *Fraxinus pennsylvanica*, *F. lanceolata*, and *Acer saccharinum* occur characteristically along stream; but *Fagus americana*, *Acer Saccharum*, *Asimina triloba*, and associated species, forming a distinct maple-beech society in some other parts of the valley, are rarely met with on the floodplain.

3. BLUFF SOCIETIES.—Like the floodplain, the bluffs are covered with forest, but of a quite different character. The woods are more open and share in common with other vegetation numerous xerophytic adaptations. Four societies need to be distinguished in an account of existing relations.

(1) *Oak-hickory society*.—Beyond the few hickories at the north, this society is little represented at the bayou. This may be partly explained by the absence of the more moist till slopes, upon which

it is abundantly represented in the vicinity. A variety of hickories is found, most common of which are *Hicoria ovata*, *H. alba*, *H. odorata*, and *H. glabra*. These are associated with *Quercus rubra*, and *Q. alba* is present.

The other vegetation also shows a number of easily recognized characteristics. The proportion of leguminous species (*Melilotus*, *Trifolium*, *Vicia*) is high; composites (*Aster laevis* and other summer-blooming species) are frequent; *Podophyllum peltatum*, *Erythronium*, *Muhlenbergia diffusa*, *Scrophularia marylandica*, and *Cornus candidissima* are common species. Counting in the smaller vegetation, the society is not rich in species, but is rich in southern forms.

(2) *Black oak society*.—The cemetery bluff conditions, brought about partly by the porous sand and partly by slope, are much more arid than the till bluffs. The hickories and red oak disappear from the forest, and *Quercus velutina* becomes most common, 53 per cent. of the individuals on the slope above the 760-foot contour line being black oaks. *Quercus alba* is common, and in places west of Ann Arbor *Q. imbricaria*.

Comparing the other vegetation with that of the oak-hickory society, it is found that equal differences exist. The May apple is rarely found; there are fewer leguminous species; ericaceous shrubs are common; and the proportion of composites is high. The vegetation is rich in species, characteristic of which are *Lespedeza capitata*, *L. violacea*, *Solidago caesia*, *S. speciosa*, *S. nemoralis*, *S. rigida*, *Gaultheria procumbens*, *Gaylussacia resinosa*, *Vaccinium vacillans*, *Angelica villosa*, *Viola pedata*, *Lupinus perennis*.

All of the numerous species of grass which clothe the steeper slopes have prominent adaptations serving to bind down and hold the soil from outwash. They are all perennials, have deep root systems, strong woody stems and rhizomes, and grow in compact tufts which offer the greatest resistance both to being torn apart and to being displaced. Even loose sand, which otherwise would be quickly washed away, is by this means held in place indefinitely, and the steepness of slope so formed is often surprisingly great. It was found that the angle of repose of the dry sand composing the bluff was $28^{\circ} 35'$. The mean angle of the slope was $39^{\circ} 55'$; or the actual slope of the bluff as held by the soil binders is $11^{\circ} 20'$ steeper than

the dry, loose sand would take by gravity alone. *Andropogon scoparius*, *A. furcatus*, *Chrysopogon avenaceus*, and *Stipa spartea* are the most common of these soil binders.

(3) *Juniper heath*.—The conifers are restricted to open or unfavorable situations, and thrive where other arborescent forms do not. Only isolated individuals of juniper and cedar are met with at the bayou; but southeast from the city are found slopes covered by them. On the brink of a bluff which has been undermined by the stream so as to leave the slopes bare of any vegetation, *Juniperus communis* makes an early appearance. From this point it throws out decumbent rooting stems, which, partly directed by the movement of the unstable soil, come to extend down the slope, and the growth is continued from above downward. A covering is soon made, in which also occur *J. virginiana*, *Lepargyrea canadensis*, *Rhus aromatica*, and *Stipa spartea*.

None of the other societies occur under conditions equally xerophytic. The juniper and cedar are most common (fig. 4), but not so characteristic of such situations as other less frequent members, like buffalo berry or porcupine grass. If we compare slopes of different ages, evidence will be found showing that the juniper slope is transformed into an oak slope as conditions become more favorable for the growth of vegetation. In the heath appear *Populus grandidentata* and *P. tremuloides* and seedlings of black locust, basswood, and oak. Cedar Bend, Ann Arbor, has gone a step farther. Here the oaks are dominant, but there is still much juniper, cedar, and aspen. Even the final black oak stage is not without decayed logs, stumps, and isolated individuals, suggesting the former prevalence of the juniper and other members of that society.

(4) *Thicket societies*.—One of the most characteristic features of the river vegetation as a whole is the large proportion and variety of shrubs which it contains. Along the bluffs these shrubs occur either as scattered individuals or mixed together as thickets or undergrowth. The numerous species of thorn and bramble, *Ampelopsis*, *Smilax*, *Celastrus*, *Vitis*, and other vines, occur most frequently in dense mixed thickets, where an open ledge or slope affords a chance. *Rhus hirta* and *R. glabra*, however, do not tend to mix with other shrubs, or even with each other, but form patches of pure growth, which distinguish at once the sumac thicket from all others.

As a whole, the bluff vegetation is made up of light-requiring species. The prevailing forest trees are among the least shade-enduring kinds to be found in the region. Such trees never crowd together to form the dense type of woods common on the floodplain; but, like the black oak woods, or like the openings of bur oak west of Ann Arbor, the trees stand far enough apart to permit an abundant



FIG. 4.—Washed slope in juniper-heath stage; the ground juniper appears in patches in the foreground, with red cedar forming a dense grove in the background; near Rawsonville, Michigan.

growth of smaller vegetation to spring up in the woods. Also there is less tendency to growth in mixture. The sumac and junipers are gregarious, and there is not the variety of trees in the oak woods that there is in case of the more mesophytic kinds. The tendency of the black oak group to occur on sands, and of the hickories to occur on clays, are among the most constant relations which societies have been found to bear to soil types.

OTHER BIOLOGICAL GROUPS.

The account thus far deals mainly with indigenous plants which seem to bear a more or less constant relation to the environment, and includes a total of 316 species which have been classified into societies. There remain eighty-four species found upon the area surveyed, which occur in widely varying situations. These have been classified into two groups.

1. THE HETEROPHYTES.—A group of twenty-one native species were found to occur in so wide a range of habitat as to be best termed heterophytes. The most common of these are *Onagra biennis*, *Taraxacum Taraxacum*, *Poa pratensis*, *Aster novae-angliae*, and *Solidago canadensis*.

2. INTRODUCED WEEDS.—A second group, the exotics, embracing the introduced weeds, is characterized by a similar wide range of habitat. Their presence is due solely to the agency of man, and serves to indicate the extent to which he has changed the composition of the original vegetation by clearing away the forest and cultivating areas in the vicinity. Nearly one-seventh of all the species collected at the bayou have been introduced. Of these fifty-two are European, four (*Amaranthus retroflexus*, *Chenopodium ambrosioides*, *Mollugo verticillata*, *Datura Tatula*) are tropical American; one (*Ailanthus glandulosa*) Chinese; one (*Lonicera Tatarica*) northern Asiatic; one (*Abutilon Abutilon*) southern Asiatic. The important fact is brought out in the study of the bayou vegetation that the aquatic and swamp societies are almost free from introduced species. Only five species were found in this area: *Solanum Dulcamara*, *Mentha piperita*, *Roripa Nasturtium*, *Salix purpurea*, and *S. alba vitellina*. These were confined mainly to the drained swamp. The juniper-heath is also nearly free from exotic species. The largest number of exotic species occurs in the grain-bearing or grass-producing societies, the highest percentage being associated with the black oak and the oak-hickory societies.

PROMINENT INTER-RELATIONS.

From the fact that members of a plant society live together under common conditions, it is to be expected that individual species of a group would possess common adaptations and hence resemble one

another. This is seen to be the case in the tamarack society, for example, where there is a marked morphological resemblance. But it is possible to trace the resemblance much further. With this in view, the percentages of spring, summer, and autumn blooming species were obtained for each society. Fall percentages were taken as positive, summer percentages as zero, and spring percentages as negative, the results being shown in the accompanying table. A

TABLE SHOWING PERCENTAGE OF SPRING, SUMMER, AND FALL BLOOMING SPECIES; AND THE PERCENTAGE OF NORTHERN, CONTINENTAL AND TEMPERATE, AND SOUTHERN SPECIES IN EACH SOCIETY.

SPECIES			TIME OF BLOOMING							GEOGRAPHICAL DISTRIBUTION						
No.	Society	No. of sp.	Spring —		Summer o		Fall +		Value	Northern —		Temperate and Continental		Southern +		Value
			No.	%	No.	%	No.	%		No.	%	No.	%	No.	%	
1	Juniper-heath..	5	5	100	o	o	o	o	-100	4	80	o	o	1	20	-60
2	Black oak.....	62	15	24	45	73	2	3	-22	4	6	29	47	29	47	+41
3	Sumac.....	2	o	o	2	100	o	o	o	o	o	2	100	o	o	o
4	Oak-hickory...	26	8	31	17	65	1	4	-27	o	o	15	58	11	42	+42
5	Walnut.....	50	20	40	30	60	o	o	-40	2	4	25	50	23	46	+42
6	Elm-ash-maple	46	22	48	24	52	o	o	-48	6	13	31	67	9	20	+7
7	Moist sedge....	3	1	33	2	67	o	o	-33	1	33	2	67	o	o	-33
8	Tamarack.....	13	2	15	11	85	o	o	-15	9	70	4	30	o	o	-70
9	Willow.....	71	32	45	39	55	o	o	-45	28	40	32	45	11	15	-25
10	Water sedge...	19	3	16	16	84	o	o	-16	5	27	13	68	1	5	-22
11	Typha-Sparganium.	10	3	30	7	70	o	o	-30	o	o	8	80	2	20	+20
12	Water smartweed ..	6	o	o	6	100	o	o	o	o	o	4	66	2	34	+34
13	Waterlily.....	5	o	o	5	100	o	o	o	o	o	5	100	o	o	o
14	Pondweed.....	6	1	17	5	83	o	o	-17	o	o	6	100	o	o	o

curve was then plotted from the summation of such percentages. The curve suggests that in general similar societies possess similar habit. The societies which bloom earliest have a high per cent. of northern forms. Like many of the willows, poplars, and maples, the flowers often appear before the leaves. Also the leaves unfold and the fruit matures before more southern types like the oak, hickory, walnut, and sycamore. The bluff societies, except for the juniper, possess the southern habit.

The trees are mainly nut-bearing and ripen their fruits, unfold their leaves, and bloom relatively late. Thus we commonly see a tamarack swamp or a floodplain forest with young foliage well along before the surrounding oaks have begun to show marked signs of life. Both curves show that the highest per cent. of vernal as well as northern forms occurs in the floodplain societies and on the juniper slopes. The highest per cent. of southern forms occurs along the favorable slopes of the bluff and in the aquatic societies.

CONTROLLING FACTORS.

1. CLIMATIC.—A number of species have been pointed out whose distribution is more or less restricted to the stream, although this will be shown to be less true near the mouth. Most common of these are the hickories, walnut, yellow oak (*Q. acuminata*), red elm, silver maple, red and green oak, sycamore, hoptree, *Rhus aromatica*, *Juniperus communis*, *J. virginiana*, *Iris versicolor*, *Meibomia canadensis*, *M. grandiflora*, *Ambrosia trifida*, *Dioscorea villosa*, *Sanguisorba canadensis*, and *Mesadenia atriplicifolia*. Most of these are near the northern limits of their range. Since many of these forms occur in a wider range of habitat in the south, it may be assumed that climate plays some part independent of other factors in causing such species to become limited to the neighborhood of the stream.

2. ATMOSPHERIC.—The fact that the forest is usually open along the edge of the bluffs seems to account in large part for the presence here of the juniper and associated species. Their behavior indicates exacting light requirements, as they thrive only in open situations, and early show a decline when shaded. To a less degree the sumac society occupies open places in a similar manner.

3. MECHANICAL.—The mechanical effects of stream erosion are continually bringing about changes of topography and soil to which the plant societies are in turn conforming. Although a number of bluffs are being denuded by the cutting of the current, the floodplain areas are not likely to be very greatly increased; since it has been shown that a stream cuts within the limits of a belt not over eighteen times the width of the stream at that point.³ The fact that *Populus*

³ JEFFERSON, M. S. W., Limiting width of meander belts. Nat. Geog. Mag. —:373-384. 1902.

and *Salix* are often the first woody types to appear on the exposed places of the floodplain and bluffs appears to be due to nothing beyond the fact that they were first on the ground. Judging from the shrubs, dispersal by wind may be more rapid than dispersal by animals, but it is certainly far less prevalent, as will be shown later.

4. EDAPHIC.—Of all the local conditions, the societies sustain the most obvious relation to the amount of available moisture in the soil. It is this which in large measure gives the distinctive characters to the bluff societies as compared with those of the floodplain or the peat-forming group. The relation which tension lines bear to water supply takes on particular interest in case of the bayou peat-forming societies indicated in the map. There is a slope toward the center in which there occurs a pond-like bay. The main part of the surface water discharged from the seepage springs along the cemetery bluff is carried to the southeast to a point near the fence, where it makes a good sized stream as it flows directly to the ponds. A similar discharge of surface water comes from several points along the elm-ash-maple zone. The map shows the general tendency of tension lines to arrange themselves concentrically about the bay; also a tendency to arrange themselves parallel to the stream, and the complex pattern of the peat-forming societies is the resultant of these conflicting tendencies.

A chemical analysis was made of the soil water about the springs in the hope that peculiarities might be detected to account for the xerophytic adaptations noticed in the vegetation. The water was found to be neither acid nor alkaline. It contains sulfates, chlorides, and carbonates, with iron, calcium, and sodium, but not different from the usual spring water. The water, however, is cold and keeps the swamp at a low temperature. There are five of the societies which stand in so definite a relation to soil types that they give fairly reliable information as to the kind of soil merely by their occurrence. The black oak society may be taken to indicate dry sand or gravels; the oak-hickory society, till or clay; the tamarack society, peat; the elm-ash-maple society, wet soils; the maple-beech society, richness of soil. Such soil relations do not appear to be limited to the valley alone, but to hold true over a considerable area outside.

5. BIOTIC FACTORS.—It is due to the interaction of one life form

upon another that there have been produced areas of turf which otherwise would have been very limited or wholly absent. Along the brink of the cemetery bluff a line of tension is easily traced. It is not sharp like the swamp lines; but, like the usual upland type, there is an area over which the societies blend. *Poa compressa*, *Andropogon scoparius*, *A. furcatus*, and *Stipa spartea* crowd their way for a distance of one to six feet into the turf of *Poa pratensis* and *Trifolium repens*, where they fade out altogether.

It is plain that animal life has played an important if not a chief part in the dispersal of seeds in the valley. Squirrels and like animals were formerly more common than now, but birds are yet numerous; the blue-jays,³ cat bird,⁴ and crow blackbird⁵ alone feed upon a variety of fruits that includes more than one-half of the woody species at the bayou, exclusive of the large trees.

Besides these, there are the red-winged blackbird, vireo, oriole, woodpeckers, song sparrows, cowbirds, and robins, which are common all along the stream and are known to devour fruits. This has resulted in scattering the seeds of a number of shrubs, vines, and small trees in the open places of the forest. At the bayou there are sixty-one species of this kind, 82 per cent. of which have adaptations for seed dispersal by animals; 72 per cent. have the brightly colored fruits eaten by birds, of these 22 are red, 10 black, 7 blue, and 5 white. It is possible that this may indicate something with regard to the relative attractiveness of the several colors.

Over two-thirds of the species with colored fruits occur in the bluff societies, and are most numerous with the juniper, sumac, and black oak. This fact is not so easily explained by any habit of the birds as it is by the character of the woods. The same relations appear to hold true of corresponding societies away from streams,

³ BEAL, F. E. L., The blue-jay and its food. Yearbook, U. S. Dept. Agric. 1896: 202.

⁴ JUDD, S. D., Birds of a Maryland farm. Bull. 17, U. S. Dept. Agric. Div. Biol. Survey, p. 104.

⁵ BEAL, F. E. L., Food of the bobolink, blackbirds, and grackles. Bull. 13, U. S. Dept. Agric., Div. Biol. Survey, p. 64.

—, The crow blackbirds and their food. Yearbook, U. S. Dept. Agric. 1894: 243.

where the forest has been undisturbed. Blueberry, barberry, blackberry, hackberry, huckleberry, raspberry, strawberry, currants, cornel, cedar, juniper, sumac, sassafras, black cherry, pin cherry, choke cherry, and black haw occur commonly in the dry sand of oak woods, less commonly with the hickories, and least of all in the maple-beech woods. Oaks, however, have thin crowns, are not shade-enduring, and do not grow crowded together, forming open woods that give a chance for the growth of a variety of herbs, shrubs, and vines on the forest floor. On the other hand, the beech, maple, and ash are distinctly shade-enduring, have thick crowns, and grow crowded together, forming a dense woods in which there is little chance for undergrowth to come in. In such woods there are so few shrubs and vines that the average woodsman is not aware of their presence at all, and finds himself at a loss to account for the thick berry patch that springs up wherever he cuts a few trees. It is plain that seeds are scattered in all woods, but only the open woods afford a chance for their growth.

6. THE HISTORIC FACTOR.—The presence of *Sarracenia* near cold seepage springs, and of the white pine on the bluffs, suggests that those plants may be relics of a past northern flora, which followed closely the retreat of the ice. While the tamarack society probably does not date back to this period in its origin, its flora may have been derived in large part from species so left, in the same way that the juniper-heath spreads out over exposures as fast as made on the bluffs. The fact that 70 per cent. of the species associated are northern adds confirmation, and accounts for the dissimilarity between it and neighboring societies. With further investigation it does not seem improbable that many if not all of the peat bog forms may be found lurking in the neighborhood of springs of this character.

Societies of the favorable places of the floodplain and bluffs have a pronounced southern flora. A few northern forms occur in all the floodplain societies; but the oak-hickory society, in which there occurs a high per cent. of southern forms, has so few northern species that their occurrence may be regarded as accidental. The curve (*fig. 5*) shows how in land situations southern tendencies fade out as conditions become more and more unfavorable.

SUMMARY

1. The bayou of Ypsilanti, as indicated in the sketch of its geological history, is of relatively late origin, and relics of postglacial floras have been nearly obliterated by more recent changes, which render the portion of the valley directly affected by the stream not so suitable for the preservation of ancient floras as the secluded swamps

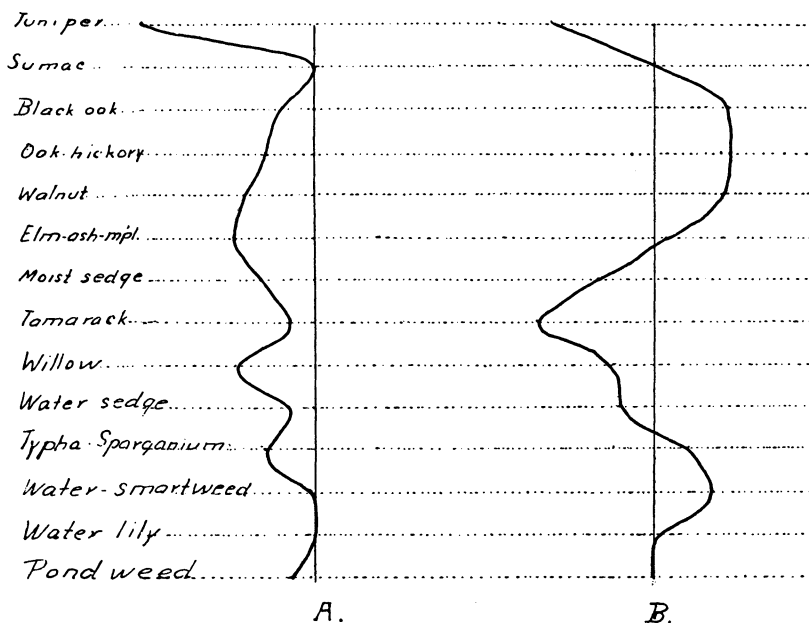


FIG. 5.—A, curve of period of bloom; B, curve of geographical distribution; curves drawn from values obtained in map.

or bogs of the morainal regions. But the seepage springs and bluff exposures of sufficient age and isolation still retain such relics of a past northern flora which followed closely the retreat of the ice.

2. The societies of river swamps, such as the bayou here described, are distinct from those of the lake swamp or bog. In both, however, xerophytic adaptations are conspicuous, which cannot be explained by the absence of drainage currents nor by the presence of humus acids.

3. The peat-forming societies show sharp tension lines, conforming to depth of water, characteristic of pond vegetation. Such tension

lines become obscured in the floodplain societies, and still more so in the bluff societies, but in each of them the relation of distribution to soil water, as a controlling factor, is plainly marked. The definite relation of certain societies to soil types, shown to exist here, appears to be due primarily to the capacity of these various soils for water.

4. Of other factors to which the plant societies are evidently related, the influence of light is conspicuously manifest, as for example in the place taken by light-requiring species in the bluff vegetation. Quite as manifest, though far more complicated, is the coincident operation of biotic factors, which are so numerous and varied in their manifold interrelations as still to demand much special study.

5. The high per cent. of northern species in early blooming societies, the occurrence of various southern forms along the river near the northern limit of their range, the occupation of favorable places by societies of distinctively southern cast, and of unfavorable ones by those of pronounced northern composition, are all indicative of the close relation of the members of these societies to slowly changing climatic conditions. A discussion of the migrations of these plants in connection with geographic and climatic changes is deferred until a greater accumulation of data has been made.

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